Menlo Park Notebook #21 [N-79-04-08.1]

This notebook covers the period April-October 1879. The entries are by Edison and John W. Lawson. Included are notes, drawings, and calculations for a series of experiments on thermoelectricity. The experiments were made with bars of metal alloys and are probably related to the alloy experiments in Menlo Park Notebook #18. The label on the front cover is marked "Thermo Experiments." The book contains 284 numbered pages.

Blank pages not filmed: 158-161, 202-203, 208-215, 218-271, 274-277.

Missing page numbers: 7, 9-13, 15, 17 [pages 7, 13, 15, 17 were renumbered as 2, 3, 4, 5].

MO 21

GENERAL ELECTRIC.

...., 189

Experiments on Thermo electricity

April 8 1879

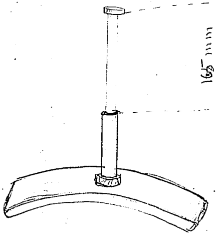
We have cast about 100 alloys and are casting several hundred more. These alloys vary by 10 per cent and besides we are to make alloys of the metals with the Arsenides, Selenides, Phosphides Sulphides, Tellurides, and also bars of powdered metals oxides etc moulded under hydraulic pressure. These bars are 128 mm in length and 12 mm thick. with holes in the ends The bars to be tested are connected

ogether by a copper strap, thickness
2¾ mm length 28½ mm breadth 14 mm
copper screws are used to secure the bars
together on the strap, the distance betwee
the bars after they are coupled is 3 mm
at the othe extremities holes are drilled
in the sides 10 mm from the end into
which the wires are inserted holes
drilled in the end have screws which
clamp the conducting wire; The
sulphides and brittle metallic alloys
have clamps instead of screws

both to secure them together and to secure the wires this device will be explaned further on.

As a source of heat I used a cube of copper with boiling water and the couple was screwed to the side of the cube by a projecting screw which entered a threaded hole in the copper strap connecting the Thermo-couple together. A Thompson Mirror Galvanometer with coarse wire was used the rescistance of which is

________ ohms - distance between the face of the galvanometer case and the scale 500 mm. directing magnet



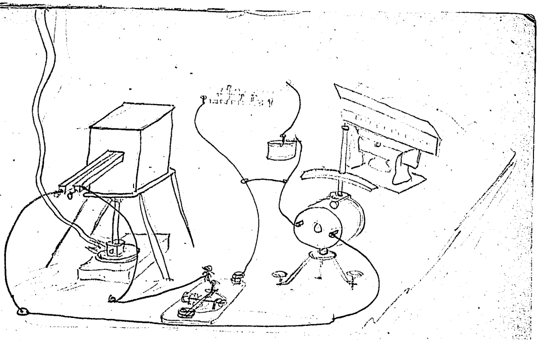
as shewn above. under these conditions one Daniells cell gave a deflection of 100 degress through 1820 ohms

150 degrees through 1245 ohms deflection of 200 through 930 ohms deflection of 250 degrees through 757 ohms deflection of 300 degrees through 642 ohms deflection of 350 degrees through 559 deg.

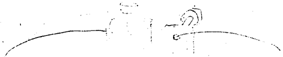
deflection to the left =

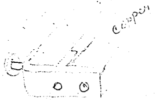
after taking these readings we find we had a thermo battery in circuit we take the readings again

Deflection	100	1870	ohms
"	150	-1270	"
"	200	: 965	"
"	250	—780	"
	300	670	"
"	350	570	"



We test every metal against copper and allow it to gain a constant temperature before taking the final reading - we have concluded to use the copper clamp both for securing the wires and the bars together.





Boiling water

		Reading	
Copper and Brittania	1st		22 deg
This has been on over 1 hour –	2nd	—	25 "
	3rd	=	25 "

We now put them on for 10 minutes & then take the reading. copper on constantly

No 77

Copper & Copper 20 pc Iron 80 per cent
put on 9 35 pm. Copper is the [illegible] —

Deflection to right 1st reading 90
2nd " 92

No 68. - 70 per cent of copper 30 p c of antimony -

945 PM -

Deflection - 1st Reading 60
To the left = 2nd " 65

No 48. 10 per cent copper 90 p c of iron
10 PM 1015

Deflection. 1st reading 115
to the right. " 115

I noticed that after 5 minutes it gave deflection of 132 This shows that the bars gradually became heated at the binding post ends.

No 23 - Sulphide ~~Lead~~ Copper

1023 pm.

Deflection - 1st Reading

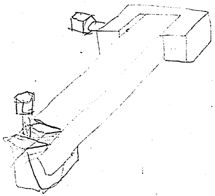
35° through 100 ohms
65 " 50 "
128 " 25
300 " 10 "

Keeps same deflection after 10 minutes, The sulphide lead is a very poor heat conductor and is scarcely warm even close to the junction while the copper is hot at the extreme end. The galvanometer is thrown violently off the scale with no resistance in -

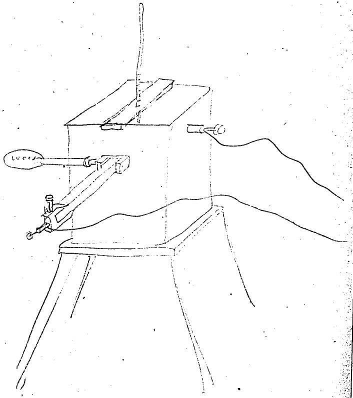
April 8. Evening - 7 15 PM

Resumption of Thermo-experiments -

we made a new clamp



we use the copper cell itself as the other bar see other page.


Lucca

We try 23 Sulphide Copper again & find it gives the same (1e) 35 deg through 100 ohms = Deflection to the left

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No 24 – Sulphide Copper after 2 minutes gives 10 deg to the left = 12 deg in 4 minutes (not full length)

---

24 - another piece marked 24 but more homogeneous – Sulphide Copper goes off the scale.. goes to 18. to the left through 100 ohms.

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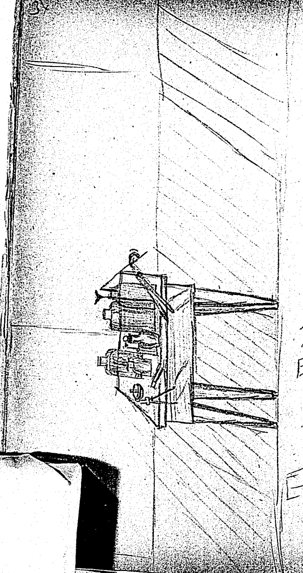
30 — 30 per cent Copper 70 of Zinc deflection 24 to the right – rises –

34



This is a Table

115

31

No 61. Sulphide Iron deflection of 115 to the left. no resis

67. 20 per cent Copper 80 percent of antimony - deflection to the left of 15 - no R.
Sluffient hair

67. 20 per ct copper 80 antimony deflection. 3. to the left

65 - 40 per ct copper 60 antimony deflection 2 to the right.

68. - 70 copper 30 antimony 7 to the left -

71 - Short bar - 10 per ct Copper 90 percent Lead - deflection to the left of 25.

---

74 - Copper 60 p.c Iron 40 p.c Deflection to the right 16.

---

75 = Copper 50 pc - Iron 50 pc deflection to the right of 15

---

76 Copper 30 pc Iron 70 pc Deflection to the right. 22

---

77. Copper 20 pc Iron 80 Deflection to the right - 20,

78 - Copper 10 pc Iron 90 pc

Deflection to the right 26 -

---

60. Bell Metal - 69 pc Copper Tin 31 percent, Deflection to the right, 8 deg

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No. 1. Steel - soft -

Deflection to the left of 8.

No 1 again 2nd bar.

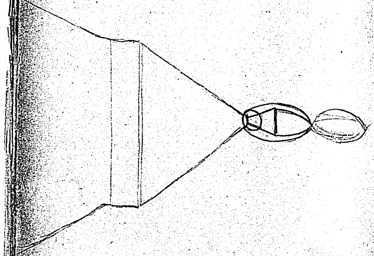
Deflection to left of 7.

No 2. Steel hardened to blue.

Deflection to left of 9,

No 2 2nd bar -

Deflection to left 8.



No3. Steel-hardened to a straw
Deflection Nil Def to left

Same - 2nd Gal. Def to left
Deflection 2.

No4. Steel glass hard
Deflection to the right, 7

Same - 2nd Gal
Deflection to the left. 5

No5 - Steel glass hard one end.
Def to Right. 10 & reverse
end - goes to the left. 5 deg

ditto 2nd Bar goes to the right - 11

No 6 - Soft Iron -
Def to left 20 deg

No 6 2nd Bar -
Deflection to left. 20.

No 7. Iron - Hard
Deflection to left. 20

No 7. 2nd Bar.
Deflection to left. 22

No 8. Case Hardened Iron
Deflection to left, 20

Ditto 2nd Bar
Deflection to left. 18

10. Composition Brass Castings
Deflection to the right of

10 deg

Ditto 2nd bar
Deflection to right 12

No 11. Common Brass
Deflection to right 15

No 11 Second bar
Deflection to right of 15

No 12. White Brass
Deflection to right of 15

Ditto 2nd bar
Deflection to right 15

13. 70 percent Copper 30 pc Zinc
Deflection to right of 12

14. 60 Copper 40 Zinc
Deflection to right of 11

15 - 80 Copper 20 Zinc
Deflection to the right 13

16. 90 pc Copper 10 Zinc
Deflection to right of 13

17. German Silver
Deflection to right of 45

Ditto 2nd bar—
Def to right of 45—

18 — Pewter
Deflection to right of 11

Ditto 2nd bar
Deflection to right 10.

19 — Brittania Metal
Deflection to right of 12

Ditto —
Def to right of 12

20 — Zinc

Deflection to right of 9

Ditto 2nd bar

Def to right of 10

---

22 - Grey Cast iron -

Def to right of 28.

Ditto 2nd bar -

Def to right. 28

---

25 — 50 Copper 50 Zinc

Deflection to right 12

---

28. 40 Copper 60 Zinc

Def to right 15

25

29 – Lead

Def to right 13

Ditto 2nd bar –

Defl to right. 13

---

45 – 30 Zinc 70 Cadmium

Def to right of 5

– White Cast iron

Deflection to right 15

---

31. 20 Copper 80 Zinc

Deflection to right 25

~~34~~

35. 70 Copper 30 Iron

to the right 25

36. Babbitt metal
Deflection to the right 5

37 — Tin.
Deflection to the right 11

38 – 90 Zinc 10 Cadmium
Def to Left. 185

40 – 80 Zinc 20 Cadmium.
to the right. 5

41. 70 Zinc 30 Cadmium
to the right. 5

42 – 60 Zinc 40 Cadmium
Def to right 4

43 — 50 Zinc 50 Cadmium
Def to right 5—

44 — 40 - Zinc 60 Cadmium
Def to right 5—

46 — 20 Zinc 80 Cadmium
Deflection ~~to right~~ Nil

47 — 10 Zinc 90 Cadmium
Def Nil

48 — Sulphide Tin — (Proto)
Def to right 12

Ditto 2nd Can —
Defl. right 12

50 - 10 Copper 90 Zinc
Deflection to the right 10

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51 - 80 Copper 20 Iron
Def to right 18 Deg not well mixed

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52 - 30 Copper 70 Lead
Def to right 10

---

53 - 90 Copper 10 Lead
Def to right 8

---

54 - 80 Copper 20 Lead
Def to right 8

---

55 70 Copper 30 Lead
Def to right 9

56 — 60 Copper 40 Lead
Def to right 8

---

57 – = 50 Copper 50 Lead
Def to right 8

---

58 – 40 Copper 60 Lead
Def to right 8

---

59 – $\frac{2}{3}$ Copper $\frac{1}{3}$ Lead
Def to right 8

---

64 — 10 Copper 90 antimony
to the left - 24

69 – 80 Copper 20 antimony
Deflection to right 5 –

70 — 90 Copper 10 antimony
Def to right 10

71 – 10 Copper 90 Lead
Def to right 11

72 – 20 Copper 80 Lead
Def to right 9

73 – 20 Copper 80 Lead
Def right 10

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April 9. 1879.

Miscellaneous Experiments with rough Masses, not very reliable,

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A Crystal or Cube of native galena 1/4 inch square on the 212 Copper Water Cube throws the light to the right off the scale; artificial Galena to the left off scale.

Lake superior stringy silver deflects right 15 deg

Native Iron pyrites. 20 to right I didnt make any ground. Carbonated

Stick of fused Tellurium about 3/4 inch long 3/16 diameter went off scale to the left – 100 Ohms inserted brought it to 55. + 175 ohms to 35 which is the same as artificial sulphuret of lead with 100 ohms in

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Chromium from J M + Co 15 to the right –

Some ore from Prize Lode Nevada Dist, (Colorado [illegible]) goes off scale to right – (one specimen goes to left)

Sulphide Bismuth about 300 to the right

Sulphide Antimony to left
about 125

Solid Sodium amalgam
18 to the right

Native Arsenic (from [illegible]) 40 to
the left.

Smaltite. from Schneeberg
Saxony 25 to the right

Cinnabar from California nil
too much Res I think

Brookite - (Ti) from
Magnet Cove Ark. Nil. too
much resistance I think

Magnetite, F Fe.
Loadstone, from magnet cove Ark
15 to the right - probably and
Cantool & R.

Allemontite, Sb-As_3-
Allemont France
Whitish part goes 300 to the right
Compact & darker part 50 to the
left -

Ullmannite, Prussia
50 to the right

Stibiconite, Var-Partzite
Mono Co Cal - 50 to the left

Bornite - Erubescite, Horseflesh
ore Chili S.A. 150 to the left

We melted the native Sulphide of Lead to a state & it still throws the light off the scale ~~[illegible]~~ to the right while the artificial Sulphide of Lead throws it off the scale to the left

Silver ore =
Lake Superior
10 to the right

Iodide Copper 60 to the left

We found that after many Experiments that fused of Selenium only goes to 250 instead of off the scale to the right but unfused Cake goes to ~~[illegible]~~ 50 to the right Tellurium went to 50 on the left the two together went to 95 on the right

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~~Silicon - ([illegible])~~

~~[illegible]~~

Pyrolusite (Binoxide Mn)

Lumps - 100 to the right Varies in different parts

Battery Carbon 2 to the right - clamped well & good connection obtained -

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Silicon (rough Ex) goes to left about 250 deg increase by pressure think this is very Sensitive

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Electromotograph points on thermo Tests

Cobalt	10	to right
Lead	1	"
G Silicon	12	"
Tin	5	"
Zinc	5	"
Arsenic	12	Left -
Antimony	10	"

Tellurium	150	to Left
Aluminum	Undecided Def nil	
Thallium	5	to Right
Iridium	2	"
Nickel	15	Right
[illegible]	5	"
Bismuth	20	"
Platinum Iridium	10	"
Brass	5	"
Babbitt Metal	3	"
Magnesium	3	"
Gold	5	"
Bisulphide Tin	4	"
Sulphide Iron		50 - to [illegible]
than the other	-	
Silver	3	Right

Sulphide Copper	1	to Right
Chromium	10	"
Gr on C.P.	1	Left
Carres Carbon	2	Right

all of pairs

Metals in Case

Iridium	2	Right
Rhodium	2	"
Zirconium	5	left

Cubanite.
from California
goes off scale to Right

A = Dimagnetite
Magnet Conc Ack 20 to Right

tetrahedrite
San Juan Co Colorado
50 to Right
Bad Contact

Atacamite. 153 - 130 Facts
Bad Contact - 1 place goes to 130
to right

Marcasite. Cartago Co. [illegible]

Powdered Black ox [illegible] [illegible]
pressed in Monel 3/8 diameter
1½ inch long pressure 15000
lbs - dont appear to deflect gal

Most Sulphur
Protosulphide lead made by
MackIntire : goes to right 28.

¼ as much
Tetartosulphide lead made
by Mac - 20 to right.

½ as much
Hemisulphide Lead made
by Mac 10 to right

25

I find that our Key has had a Capricious resistance in it [illegible] all these tests are unreliable -

---

without Key -
Tellurium through 100 ohms goes to 50 to the left
Cube of Native PbS goes 48 to right -
Sulphide Copper 35 to left.
Fused Sulphide ~~Pb~~ Lead ~~goes~~ ~~[illegible]~~ 5 to right.
all through 100 ohms
Bismuth 14 to right -

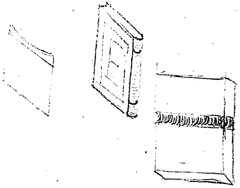
Cube of Galena from Joplin Mo only goes to 30 ~~to right~~ through 100 ohms

fused Native Sulphide. galena
goes 25 to right through
100 ohms

April 10 —

For some unknown reason the galvanometer is more sensitive this morning probably the permanent adjusting [illegible] of the controlling magnet has weakened. Bar of Sulphide Copper goes to 50 — [illegible] Bismuth 10 right — Tellurium 55 left — through 100 ohms This seems to be better for Sul Copper

Same for Tellurium — perhaps this increased delicacy with Sulphide Copper is due to larger mass which has got cold while the Te & Bismuth was quickly warmed



both by hand & by the Cube -
this accounts for it -

Fe 80, Tungsten 20 pc
no deflection through 1000
ohms 100 or no resistance
to the right -

Sulphide Cadmium 50 pc
Sulphide Lead 50 pc
goes to 15 to right through
100 ohms. While Art Proto Sulphide
Lead only to 5.
Cube Galena goes to 45 to
right -

(through 100 oh)

Graphite Native, nix through 100 ohms

Hematite, from Ishpeming Mich nothing through 100 ohms

Margarite nix

Zincite, from Franklin NJ in one spot 15 to right 100 ohms

Pyrosulite fm Georgia 5 to right in spots. 100 ohms

Best yet

Chalcopyrite $CuS + FeS_2$ from Chili - goes to 100 to the right. on 100 ohm

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Seybertite, ng.

---

10 per cent, Zinc 90 per cent of antimony - 10 deg to the left. through 100 ohm

---

40 15 ~~per~~ ct zinc, 60 antimony goes to 18 to left through 100 ohs

12

20 percent Zinc 80 antimony
8 to the left through 100 chs

---

30 per ct Zinc 70 antimony
12 to the left through 100 chs

---

20 pc Copper 80 antimony 3 to
the left. 100 chs —

Copper & Tin Sulphide
Equal parts. 10 to the left
through 100 ohms

Has high resistance or bar is porous when I connect near Cube it goes 35 to left through 100 ohms If I put it quite close but get anything much have to put it 2 inches from the Cube Clamp. Is a bad bar

---

Foil & [illegible] 5 to left
through 100 ohms

Chalcopyrite from Colorado
also in spots goes to 50,
with 100 ohms

Arsenopyrite, or Siderite,
or Pyrrhotite in spots give
jump to the left to right

Sulphide Antimony 8 to
the left through 100 ohms
water not quite boiling

Same. Boiling

---

2 grammes Cadmium Sulphide
18 g " Lead "
goes 20 to the right on 100 ohm

16 grams Lead Sulphide
4 " Cadmium "
goes 8 to the right 100 ohms

Silicon goes to 40 on left 100 ohms & I think if I could get pressure it would go much higher.
Try in a tube

Meteoric iron small Shaving 5 to the right through 100 ohms

---

17 grams Copper Sulphide
15 " Iron "
2nd pouring
8 to right

27 grms Cu_2S
15 " Fe.S. 100 ohms
2 " Pb.S.

3 to the right

---

23 grms Cu
41 " Fe 100 ohms
36 Sulphur

3 to right

---

28 grms Cu
7 " Fe 100 ohms
21 S.

10 to right

23 grms Cu
21 " . Fe   100 ohm
46 " . S

5 to right   The Magnetic N.G.

---

54 grms Fe
108 arsenic 100 oh
N.G.

Unknown Solid Ore that MC Said was Galena & Mineral. Pb, Sb As &c or allemontite goes to 28 - to right on 100 ohms

Dont get deflection with metallic Arsenic in 100 ohms

Selenide of Pb made by melting Pb & adding Selenium goes about 10 to right

---

Phosphide Antimony 4 to the left through 100 ohms

---

80 Pb. 20 Cd. nix —

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70 Pb. 30 Cd nix
50 Pb. 50 Cd [illegible] 6
the right 100 ohms

90 Pb 10 Cd - sm to right

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50 Pb 50 Cd - nix

---

40 Pb. 60 Cd nix

60 Pb. 40 Cd nix.

Iodide of Copper in glasstube Copper plunger gave 15 to left continuing and as I Cu - gave full action 150 to right this died away after H_2O dried out & then showed 15 to left

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Peroxide Manganese
goes to 10 Ω right
by pressing powder
between Cu plates
hard 100 ohms

Di'Sulphide Tin-Mosaic
gold - non conducting
powder.

Bronze Gold powder Zinc
+ Tin - poor Conductor Thermo
NG.

Ores

Magnetite. Essex Co NY
2 to right

Pyrite $Fe.S_2$ - 40 to
Virginia
the left - nice sample -

Chalcocite = Utah -
10 to left...

54 grains Cu. 108. Arsenic
N.G.

22 grms Fe, S.
13 " Cu, ~~Metallic~~
NG.

Copper arsenide & Iron
Equal parts - NG = Its nice
alloy

Cu arsenide.
Cu sulphide. Equal part
5 to left Nice Alloy

75 grms Lead
30 " arsenic, NG

38. grms antimony
62 " arsenic
NG

70 grms Bismuth
5 arsenic,
10 to right

34 - grms Cadmium
27 . Arsenic = 10 to right

Al_2O_3 - Zinc
Sulphide Sodium - Charcoal
NG

20 grms Feldspar
20 Cu. S. NG -

Sulphid Fe + Copper Metallic
heated long time NG

Heated Sillimanite
Ng

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24 grms Fe.
18 " S. Ng

---

18 grms Cu_2S
26 " Fe.S. (magnetic.
1.0 to left

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molybdite - Cu.S. Fe S.
Pb S. Bi.As - Cd As -
CuO. Feldspar. Sulphur
10 to right

Sulphide of Copper

		Right	Left
(23) Sulphide of Copper + (1)	Soft Steel		5
" " " + (2)	Blue Steel		5
" " " + 3	Straw Steel		9
" " " + 4	Glass hard Steel		9
" " " + (5)	" " in copper acid		10
" " " + 6	Iron Soft		5
" " " + 7	" Hard		5
" " " + 8	" hardened		5
" " + 9	Copper		10
" " + 10	[illegible]		5
" " + 11	Brass [illegible]		10
" " + 12	Brass White		5
" " + 13	70% Cu + 30% Zn		6
" " + 14	60% Cu + 40% Zn		8
" " + 15	80% Cu + 20% Zn		5
" " + 16	90% Cu + 10% Zn		5
" " + 17	German Silver		9
18	Pewter		10

[illegible]			Right	Left
"	"	"		
"	"	"		
"	"	"		
"	"	"		
"	"	"		
"	"	"		
"	"	"		
"	"	"		
"	"	"		
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"	"	"		
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"	"	"		
"	"	"		
"	"	"		
"	"	"		
"	"	"		
"	"	"		
"	"	"		

Sulphide of Copper

					Right	Left
"	"	"	+ 19	Britania		5
"	"	"	+ 20	Zinc		5
"	"	"	+ 21	White cast iron		10
"	"	"	+ 22	Gray cast iron		10
"	"	"	+ 24			–
"	"	"	+ 25	50% Cu 50% Zn		9
"	"	"	+ 26	50 parts Cu 60 parts Zn		5
"	"	"	+ 27	50% Cu 50% Zn		5
"	"	"	+ 28	40% Cu 60%		5
"	"	"	+ 29	Lead		10
"	"	"	+ 30	30% Cu + 70% Zn		15
"	"	"	+ 31	20% Cu + 80% Zn		8
"	"	"	+ 32			
"	"	"	+ 33			
"	"	"	+ 34	10% Cu 90% Zn		10
"	"	"	+ 35	70% Cu 30% Iron		5
"	"	"	+ 36	Babbitt metal		9
"	"	"	+ 37	Tin		10
			38			
			39			

Sulphide of Copper			Right / Left
" " "	40	80% Zn 20% Cadmium	5
" " "	41	70% Zn. 30% " "	5
" " "	42	60% Zn 40% " "	10
" " "	43	50% Zn 50% " "	10
" " "	44	40% Zn 60%	10
" " "	45	30% Zn 70% "	10
" " "	46	20% Zn 80% "	10
" " "	47	10% Zn 90% "	14
" " "	48	Sulphide of Zinc	20
" " "	49		
" " "	50	10% Cu, 90% Zn	15
" " "	51	80% Cu 20% Iron	10
" " "	52	30% Cu. 70 Lead	13
" " "	53	90% Cu. 10% Lead	10
" " "	54	80% Cu. 20% Lead	10
" " "	55	70% Cu. 30% Lead	10
" " "	56	60% Cu. 40% Lead	10
" " "	57	50% Cu. 50 Lead	13
" " "	58	40% Cu, 60% Lead	15
" " "	59	66⅔% Cu, 33⅓ Lead	10

Sulphide of Copper

				Right Left
„	„	60	Bell metal [illegible] Tin	10
		61	Sulphide of iron	13
„		62	60% Cu + 40% Sb	15
„		63	50% Cu + 50% Sb	15
		64		
„	„	65	40% Cu + 60% Sb	15
„	„	66	30% Cu + 70% Sb	14
„	„	67	20% Cu + 80% Sb	15
„	„	68	70% Cu + 30% Sb	12
„	„	69	80% Cu + 20% Sb	15
„	„	70	90% Cu + 10% Sb	13
„	„	71	10% Cu + 90% Pb	14
„	„	72	20% Cu + 80% Pb	15
„	„	73	20% Cu + 80% Pb	15
„	„	74	60% Cu + 40% Fe	10
„	„	75	50% Cu + 50% Fe	10
„	„	76	30% Cu + 70% Fe	10
„	„	77	20% Cu + 80% Fe	15
„	„	78	10% Cu + 90% Fe	15
		79	90% Zn + 10% Sb	14

			Right	Left
Sulphide of Copper		80	80% Zn + 20% Sb	15
"	"	81	70% Zn + 30% Sb	15
"	"	82	60% Zn + 40% Sb	15
"	"	83	50% Zn + 50% Sb	17
"	"	84	40% Zn + 60% Sb	18
"	"	85	30% Zn + 70% Sb	20
"	"	86	10% Zn + 90% Sb	20
"	"	87	20% Zn + 80% Sb	15
"	"	88	90% Pb + 10% Sb	20
"	"	89	80% Pb + 20% Sb	19
"	"	90	70% Pb + 30% Sb	15
"	"	91	60% Pb + 40% Sb	17
"	"	92	50% Pb + 50% Sb	15
"	"	93	Copper Phosphide	10
"	"	94	Bell metal 78 Cu 22 Sn	15
"	"	95	Muntz metal 56 Cu, 43¼ Zn + 3¾ Pb	10
"	"		Muntz metal 56 Cu, 40¼ Zn, 4.5 Pb	17
"	"	96	10% Pb + 90% Sb	16
"	"	97	20% Pb + 80% Sb	15
"	"	98	30% Pb + 70% Sb	17

Sulphide of Copper			Right	Left
″	99	40% Pb + 60 Sb.		15
″	100	Rose metal 40 Pb 60 Sn. 100 Bi		20
″	101	Lead Phosphide		15
″	102	Tin Phosphide		15
″	103	Iron Phosphide		15
″	104	Copper & Tin Sulphides		3
″	105	Nickel Sulphide		15
″	106	90% Pb + 10% Cd		15
	107	30% Pb + 70%		15
	108	70% Pb + 30% Cd		12
	109	60% Pb . 40% Cd		20
	100	80% Pb . 20% Cd.		30
	111	40% Pb 60% Cd		20
	112	50% Pb 50 Cd		15
	113	Phosphide.		35

Sulphide of Copper

Antimony Sulphide Right Left 25

SnS } Equal Parts
Cu_2S } 20 grm

It acts very strang It went to about 40° to the left & then backwards & forward, would not stay at one place.

SnS 30 grm
Cu_2S 10 grm

It gave a deflection of about 10° to the left but would not stay there, acting in a sort of a restless way

Sn S 10 gm
Cu_2 S 30 gm

Deflection of about 1° to the left but [illegible]

Ni S 30 gm
Bi S 10 gm

Deflection of about 1° to the right

Sn S 20 gm
[illegible] S_3. 20 gm
[illegible] give no deflection

Sn S 10 gm
Bi_2S_3 20 gm

About 5° to the left

SnS 20 gm
Bi_2S_3 10 gm

A deflection of about 10' to the left

NiS 20 gm
Bi_2S_3 20 gm

It gave no deflection

NiS 10 gm
Bi_2S_3 30 gm

It gave a deflection of about 5° to the right.

20 grms Pb
20 grms Cu } + S
20 Sb

It gave me a deflection of about 15° to the right

80 grm Pb
25 S
50 Cu

It gave a deflection of about 17° to the right

Ferric Oxide Metallic Copper + Sulphur

a deflection of about 10° to the right

Lead Sulphide } equal parts
Copper Sulphide } 20° left

Lead sulphide 50 grm)
Copper sulphide 10 grm)
7° to the right

Lead Carbonate
Copper Oxide 5° to the left
Carbon bisulphide

Iron ; Copper Zinc
Cadmium ; Sulphur
15° to right

12 grm Sn + 12 Cu + S
5° to the left

8 grm Pb + 4 grms Sb + 2 [illegible] S
10 to left

14 gm Bi + 20 grms Cu + S
10 right

Cu_2S + Zn ..
Deflection 35 to the ~~right~~ Left

---

7 Sb + 6 Cd + 27 Cu_2S
On a bright spot
it gave a deflection
of about 30° R while
on other places it
went as far as 15 to
the right

Sulphate of Copper

Old bar. 45°

New ones

1	10°	left
2	5	"
3	8	"
4	n.g.	0°
5	6	"
6	5	"
7	5	"
8	7	"
9	9	"
10	10	"
11	5	
12	5	

Tellurium   October-79   JWLawson

Through 100 Ohms 100° to ~~the~~ left

Bismuth Phosphide, 20° ~~right~~
Zinc " N.G—
Tin " "
Copper " "
Tin Arsenide "
Nickel " "
Antimony "
Grey cast iron fused with Tungstic oxide N.G—
Copper sulphide fused with Molybdic acid N.G—
Zinc Arsenide N.G—
Iron " "
" Phosphide "
Nickel " "

Copper Phosphide + Zinc Arsenide, N.G.

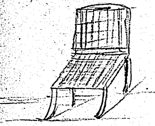
Cobaltic Oxide, 10° Left

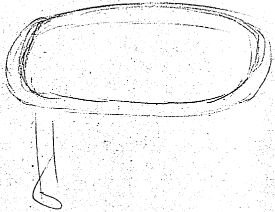
Double Phosphides Copper & Nickel N.G.

Sulphide of Copper & Zinc 10° Left

Copper & Iron sulphides 5° Right

$Cu_2S + As_2S_3$	70°	left
$Cu_2S + Sb_2S_3$	5°	"
" + As_2S_2	15°	right left unsteady
" + BaS	20°	left
" + SnS	36°	"
" + Hg_3S_2	25°	"
" + CaS	30°	"
Cu_2S + $PbSO_4$ equal weights	20°	"
" + Antimonia Arsenic "	20°	"
" + Pb_3O_4, Cryst. "	10°	"
" + Lead arsenide "	10°	right
" + Antimony Diaphoretic "	10°	Left
" + " Crocus "	35°	right
" + ZnS "	20°	Left
" + Sb_2S_5 N.G.		





$CuS + PbS$	15° right
$Cu_2S + MoS_2$	5° "
$Sb + K$ Alloy	15° "
$Pb + Hg$ "	N.G.
Cobalt Arsenide	"
" Phosphide	5° right [illegible]
Nickel "	[illegible]
Copper Antimonide	"
Copper Phosphide alloy [illegible]	"
Copper Antimonide + Bismuth Phosphide Nickel Phosphide + Zinc Phosphide Antimony Arsenide + Copper Phosphide Cobalt Arsenide	N.G.
Lead Sulphide 2 + Nickel Phosphide 1	10° right
Phosphorus Bronze 7o 8b	N.G.
" Copper " Phosphide + Tin Sulphide	5° " left
Tin Sulphide	10° "
Copper Phosphide + ~~Double~~ Sulphide Carbo	5° "

801

Copper Phosphide + Copper Antimonide	(N.G. 13)
" + Iron Phosphide	"
Sulphur, Arsenic & Antimony	"
Artif Iron Pyrites	25° left
$PbS + Sb$	5° right
$Cu + Zn +$ [illegible]	N.G.
" + " + Cu_2S 24	"
$Cu_2S + As$	20 volts Good [illegible] sounder
" + Sb	25° Left Good con-
" + P	" " " "
" + Graphite	
$PbS + Sb$	10° right, = [illegible] con
Fused PbS	N.G.
$Cu + Sb + As$	
Massive Graphite	100 ohm " lamp = 30°

Covered bars of carbon with copper film deposited by electrolysis, ~~then~~ exposed to fumes of sulphur, to convert ~~the~~ copper film into sulphide; by this means obtained bars of carbon coated with films of copper sulphide

No Good

Prepared a combination by casting a bar of lead and then encasing ~~it~~ with ~~the~~ double sulphide

Def. to left – 5° at first; by remaining on circuit went up to 25°

Cast a bar of lead sulphide and then coated with metallic copper. By placing ~~the~~ sulphide end in ~~contact with~~ ~~the~~ cube and ~~the~~ copper with ~~the~~ other pole obtained a deflection of 35° to right

---

copper sulphide treated in same way not much good

Metallic copper encased with double sulphide —

Def. 7° to left.

Cast a bar of Lead Sulphide which gave good results —

Took ~~the~~ sulphide broken into small pieces, mixed with sulphur & melted in graphite crucible, then cast

Def. 45° bright

allowed part to crystallize in crucible

Def. 60° bright

Low resistance

Repeated the operation — results Bar, 25°

Button 40°

Mixed the coarsely powdered sulphide with sulphur, and fused in graphite crucible; allowed to crystallize in button in crucible

Def 50° & 53°

Cast ~~two~~ bars each sulphide
Melted the sulphide with excess of sulphur
Both gave def. 10° left

Two bars lead sulphide
Same as preceding (excess sulphur)
Def. 75° right

Broke these bars into small pieces, and mixed equal weights of the two sulphides with sulphur and fused in graphite crucible & then cast in bars

Def. 10° to left.

Giving same deflection as copper sulphide alone.

Broke these bars into small pieces, and fused in crucible without sulphur, and cast again.

Crystalline fracture larger and coarser

Def 20° to left.

Repeated the operation

Def. 85° to right

The bars very homogeneous, fracture fine grained.

The button ~~that~~ remained in the crucible was of a coarse crystalline fracture and gave a deflection of but a few degrees, 25°-30°

Repeated ~~the~~ operation

Def. 70° at first, going up to 85° to right.

Fracture crystalline

Refused ~~the~~ bars once more and recast.

Def. 85° to 95° to right

Bars very homogeneous, fracture

crystallo-granular, not quite so fine grained as in former experiments. Cast the bars ~~Burke~~ thin at a comparatively low heat.

Re-fused once more and cast.

Def. 45° to 65° Bright

Bars homogeneous, fracture fine grained – Cast at low heat

Re-fused once more and cast.

Def. 75° Bright

Fracture crystallo-granular

Broke these bars into small pieces and fused with excess of sulphur in graphite crucible, then cast into bars

Def. 15° to Left

Fracture even, fine grained.

Allowed it then to crystallize in crucible. Fracture uneven, crystalline.

Def. same as bars

Broke the bars into small pieces and fused with more sulphur.

Def. 10° to left

Fracture uneven, crystallo-granular

Refused the bars with more sulphur, and recast.

Def 7° to left -

Bars very homogeneous, fracture conchoidal, fine grained; breaks along the longer axis of the bar in long strips

---

Re-fused the bars with more sulphur, and recast.

Def. one bar 6°, the other 10° left

Fracture coarse crystalline.

Remelted the bars without sulphur, & cast.

Def. 15° to left;

Fracture uneven, crystalline.

Re-melted the bars without sulphur.

Def. 35° to 50° bright

Fracture uneven, crystalline; one end of both bars fine grained – so that the bars were not homogeneous throughout.

Remelted again

Def. 30° to 35° bright

Fracture crystalline

Remelted again.

Def. 25° bright

Less internal resistance due to film of metallic copper on end of bar.

Fracture uneven, radio-crystalline; longer axis of bar common centre of radiation of crystals

---

Re-melted again.

Def. 20° to right

Low internal resistance (due to film [illegible])

Fracture uneven, radio-crystalline

Re-melted again at lower heat =

Def. 12° & 16° to right

Fracture crystalline, vitreous lustre

Remelted again.

Def. 3° to left.

Bars very brittle, full of cracks when taken out of mould; fracture uneven, crystalline, lustre vitreous, iridescent =

Re-melted again
Def. 15° to right
Fracture uneven, crystalline,
lustre vitreous.

Re-melted again
15° ~~to right~~ left.

Remelted again
Def 20° to left.
Fracture uneven, crystalline lustre
vitreous, iridescent.

Re-melted again.
Def. 20° to left. same as preceding
~~[illegible]~~

Fused together equal weights of Cu_2S & PbS in graphite crucible & cast two bars

Def. 15° to left

Fracture uneven, crystalline

Remelted ~~the~~ bars, and recast:

Def. 10° to right

Fracture uneven, crystalline

Remelted again

Def. 10° to right

Fracture uneven, lustre vitreous

Remelted this time with sulphur. Def. 3° to left

Fracture fine grained.

Cast at low heat: Internal series, clean

Remelted again without sulphur.

Def 10° to left.

Fracture even, finely crystalline

Remelted again.

Def. 15° to left.

Lead Sulphide

Gives deflection to right; with excess of sulphur gives deflection to left.

The phenomena exhibited by lead sulphide in its thermal properties seem to be entirely dependent on the amount of sulphur it contains

Containing a certain amount it gives no deflection, its internal resistance is great. Call this quantity x. Containing a less quantity than x it deflects to the right, but its internal resistance is small; containing a greater quantity then x up to a certain point it deflects to the right and the internal resistance is very low; passing beyond that point the deflection is to the left, and the amount of deflection & resistance seem to be inversely as the amount of sulphur contained in the bar, the greater the excess of sulphur the less deflection and the lower the resistance, and conversely

16 oz. $CaCl_2$
15.28 oz Na_2CO_3 } =

{ 14.45 oz $CaCO_3$
16.865+ oz NaCl

OFF

16 oz $CaCl_2$ + 16 oz Na_2CO_3 =
14.45 oz $CaCO_3$ + 16.865+ oz NaCl + .72 oz Na_2CO_3

32
31.28
.72

111 : 100 :: 16 : X
16
111) 1600.0 (14.45
111
490
440
500
444
560
555
5

16
15.28
31.28

14.45
16.86
31.31

106 : 117 :: 15.28 : X
15.28
10696
1528
1528
106) 1787.76 (16.865
106
727
636
917
848
696
636
60

1 lb. Carb Soda + 10 H_2O
1 lb. Chloride Lime + 10 H_2O

$CaCl_2 + Na_2CO_3 = CaCO_3 + 2NaCl$

Ca Cl Na CO
40 35.5 23 60^3
$CaCl_2 = 111$ $Na_2CO_3 = 106$
40, 71 46, 60

46
71
117

111 $CaCl_2$ + 106 Na_2CO_3 =
100 $CaCO_3$ + 117 NaCl

~~[illegible]~~

111 : 106 :: 16 : X
16
636
106
111) 1696 (15.28
111
586
555
310
222
880
888

Lead sulphide as former

(Page 205)

(1) Melted 70 grams of the sulphide prepared in the ordinary way (i.e. by heating metallic lead in contact with excess of sulphur) in graphite crucible without addition of sulphur, and cast.

(2) 70 grams of this sulphide together with 10 grams of sulphur, both pulverized and mixed

(3) 70 grams sulphide with 20 grams sulphur; both in pulverized state and mixed -

(4.) Same as preceding, except that greater amount sulphur 35 grams

(5) 70 grams sulphide with 20 grams free sulphur; after fusion, 10 grams more sulphur were added, and when in the liquid state was cast.

(6) Same as preceding; except that 20 grams free sulphur were added after fusion instead of 10.

(7) 70 grams sulphide together with 10 grams sulphur were mixed in graphite crucible and fused, then 10 grams more free sulphur were added, and before all the free sulphur was driven off the whole was poured into mould -

(8) Same as preceding, except 20 grams free sulphur were added after fusion -

(7) 70 grams sulphide were mixed with 10 grams sulphur and fused in graphite crucible a piece of roll sulphur was ~~[illegible]~~ ~~placed~~ in crucible while the sulphide was in a state of fusion, and before all of the free sulphur had volatilized the whole was poured into mould —

(8) Same as preceding except 20 grams sulphur were used instead of 10 -

(9) Prepared ~~the~~ sulphide by heating metallic lead in contact with sulphur. This was then broken up and mixed with more sulphur and

heated until ~~the~~ excess of sulphur was all driven off (dull red heat); part of this was then mixed with a small amount of sulphur and fused; ~~after~~ when well liquified it was cast =

(10) Same as preceding except; after liquefaction had taken place it was kept in the fire for 30 minutes - it was then cast.

(11) Same as preceding; instead, however, of being kept in the fire for 30, it was kept in for 60 minutes =

(12) Same as No. 9, except, after liquefaction, a small piece of roll sulphur was introduced, and before the excess of sulphur was driven off it was cast =

(13) A small quantity of free sulphur in bottom of mould otherwise same as preceding

(14) Same as (12) —

~~[illegible]~~

Filled graphite crucible wi caustic lime and imbeded bar of sulphide in it, put in fire and exposed to bright red heat for an hour in

20

1 Daniels Cell Through 6200
Ohms = 115°

Different samples of lead
sulphide gave the following
results Through 3150 Ohms

17° 23°, 16° 25°

115° ÷ 17° = 6.8 × 2 = 13.6
115° ÷ 23 = 5 × 2 = 10
115° ÷ 16 = 7.8 × 2 = 14.4
115° ÷ 25 = 4.6 × 2 = 9.2

Double sulphide lead & [illegible]

15° [illegible] ÷ 15° = 7.8 × 2 = 15.6

---

1 Daniels Cell. Through
6200 Ohms = 275°

[illegible] of
lead Sulphide
No. 1 Through 3100 Ohms [illegible]
= 15°
No. 2 "
= 35° , R = works poor about 11 Ohms
No. 3 Through [illegible]
= 21° R = .24 Ohms (Calc [illegible])
No. 5 Through 31[illegible]
= [illegible] R 1.2 Ohms
No. [illegible]
65° R 2.3 Ohms
No. 6 " works poorly R .2 Ohm
= [illegible]
No. 4 [illegible] works poor [illegible]
No. 5 [illegible] = [illegible]
R = 2 Ohms

| Daniell Through 2[illegible] Ohms
= 282°

(9). Through 3100 Ohms = 30°

(10) " " " = 20°

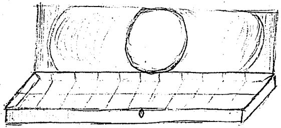
([illegible]) Tellurium Through 300 Ohms
= 140°

Through 300 Ohms = 48°

(12) " " " = 26°

(13) " " " = 34°

(14) " " "



This is ment for a box

This is a box of some kind

This is some kind of a box

A box of some kind this is

HN 1.5 $\cancel{4} = 8$

HCl. $3' = 6$

$4\overline{)14'} = 4$ lbs.

3.5

1 Daniels all through
6200 Ohms 145-0

~~Noe's Thermopile~~

~~Internal resistance~~ 1 Ohm

Hauck's Thermopile

E.M.F. about ½ Daniels

Flame (which comp.)

impinging on all the ends of elements

R. 1.2 Ohms

~~15 elements 5~~

20 - 5 = 15 elements

Edison's Thermopile

E.M.F. 1/4 Daniels

R .3 Ohm 4 elements

~~Noë's Thermopile~~

~~Internal resistance 1 Ohm~~

Hauck's Thermopile

E.M.F. about ½ Daniel's

Flame (of hint-lamp)
impinging on all the ends
of elements

R. 1.2 Ohms

~~15 elements~~

20 − 5 = 15 elements!

Edison's Thermopile

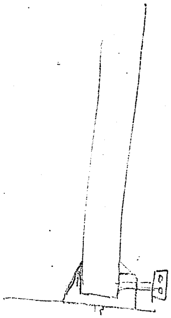
E.M.F. ¼ Daniel's

R .3 Ohm 4 elements

---

1. Daniel's Cell Through
6200 Ohms 145-0

so ~~that~~ the bars are more homogeneous in this last ~~lot that~~ is do not contain any globules of metallic lead as the ~~the first~~ lot.

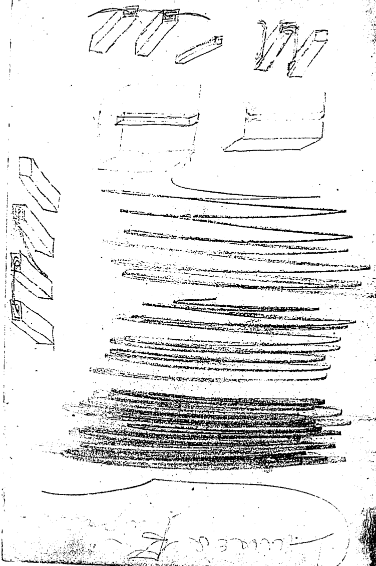


Thermo Experiments
with ~~the~~ double Sulphide of
Lead & Copper—

The first lot of bars prepared some time ago gave deflection of 15 to 25° to right

The last lot cast gives but 5° to left

The double sulphide was prepared alike in both cases with this exception that in ~~The~~ last lot sulphur was added to the mixture of pulverized sulphides before fusing in crucible



$4HCl + 2NaHO$

$HCl + NaHO$

$NaCl + H_2O$

30)100(33.3
90
10.0

[illegible] ox [illegible]

1.30)10.00(7.69
910
900
780
1200
1170
30.0

7.570

264

30)100(3.33
90
10,0
9,0
1,0,0

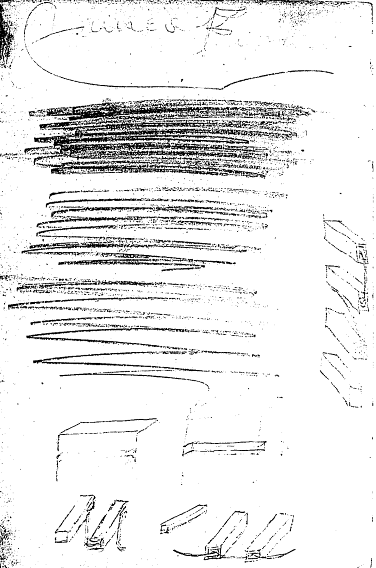
Cholin X pot/pota [illegible]
[illegible] 8.0

(1.30)1000(7.69
910
900
780
1200
1170
30,0

7.50

$2HCl + 2NaOH$

$HCl + NaOH$

$NaCl + H_2O$